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(71) Applicant: YAMAHA HATSUDOKI KABUSHIKI  
KAISHA  
2500 Shingai  
Iwata-shi Shizuoka-ken, 438(JP)

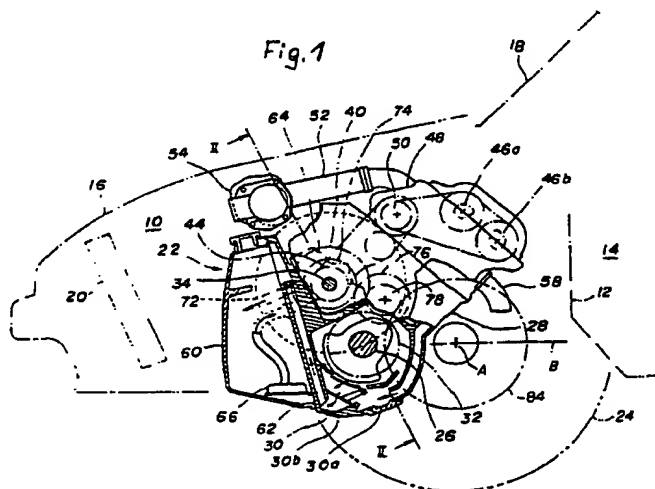
(72) Inventor: Okui, Kaoru  
161-158 Toshin-cho  
Iwata-shi, Shizuoka-ken 438(JP)  
Inventor: Kobayashi, Manabu  
4-1-3, Fujimi-cho  
Iwata-shi, Shizuoka-ken 438(JP)

(74) Representative: Patentanwälte Grünecker,  
Kinkeldey, Stockmair & Partner  
Maximilianstrasse 58  
W-8000 München 22(DE)

(54) A multi-cylinder internal combustion engine.

(57) A transversely mounted in-line multi-cylinder engine drives an output shaft (34) supporting a torque converter (72) of an automatic transmission or the clutch of a manual transmission. The shaft (34) is disposed forward of the crankshaft (26) and above it,

while the differential (80, 84) is placed rearward of the crankshaft under the inclined cylinder block (28) to provide a compact arrangement.



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## MULTI-CYLINDER INTERNAL COMBUSTION ENGINE

The present invention relates to a multi-cylinder internal combustion engine as indicated in the preamble portion of claim 1.

In vehicle engines there is a rotating member of larger diameter provided, such as a torque convertor or a clutch which will become bulky and its outer diameter will become large with the increase of the engine output. Conventionally this torque convertor or clutch (depending what type of transmission is used) is supported through the crankshaft resulting in an undesirable increase of the total engine height and, moreover, increasing the length of the engine in the direction of the crankshaft axis. Thus, the design freedom for accommodating the engine on the vehicle was affected and restrictions have occurred on the industrial design of the car, specifically undesirable in the field of passenger car manufacturing.

In some cases the engine, as a transverse engine, is mounted between a pair of left and right driving wheels inducing a lateral extension of the crankshaft substantially perpendicularly to the travelling direction of the car, adapted to drive said driving wheels through a transmission and a differential mechanism. In such a case it is necessary to keep the torque convertor or the clutch for the transmission apart from the axle shaft provided for transmitting the rotation of the differential mechanism to each of the driving wheels in order to prevent any interference with the differential mechanism or the axle shaft. Therefore the crankshaft, the torque convertor or clutch and the cylinder block have frequently been positioned relatively far distant from the differential mechanism and it was necessary to provide a large engine compartment which is undesirable from the viewpoint of vehicle height and vehicle design freedom.

Accordingly it is an object of the present invention to provide a multi-cylinder internal combustion engine which has a small total height and is capable of being easily accommodated within a small engine compartment, in particular suited to serve as a transverse engine having a row cylinder arrangement.

The afore-indicated objective is achieved by means of a multi-cylinder internal combustion engine as indicated in the preamble portion of claim 1, said engine being characterized in that, the output shaft which rotates integrally with the crankshaft is disposed on one side with respect to a vertical plane containing the axis of the crankshaft opposite to the differential mechanism which is disposed on the other side with respect to said plane, said output shaft extending in parallel with

the crankshaft. Moreover the rotating member of large diameter, i.e. a clutch or torque convertor supported by said output shaft and the main shaft of the transmission are disposed coaxially with the output shaft, said rotating member of large diameter overlaps the crankshaft in the side view and the cylinder block is inclined in such a manner that it covers the differential mechanism from above.

The advantageous effects of the engine structure according to the present invention as indicated above are indicated hereinafter and result in a considerably compacted layout of the engine which enables to perfect the accommodation of a multi-cylinder engine, having for example six cylinders in a row, disposing said engine transversally in a very small engine compartment. Since the main shaft of the transmission is disposed coaxially to the output shaft which, in turn, is positioned in parallel and slantly above the crankshaft, the rotating member of large diameter such as the torque convertor or the clutch are positioned on said output shaft and will not project downwardly from the engine. Moreover, as the cylinder block is inclined in such a manner that it covers the differential mechanism from the top, the height of the whole engine can be kept minimal even if a portion of the large reduction gear of the differential mechanism projects downwards. A main advantageous design feature attained through the present invention resides in the fact that it becomes possible to dispose the crankshaft very close to the differential mechanism as the output shaft on which the clutch or torque convertor is supported is located on a side of the crankshaft opposite to the position of the differential mechanism. Finally, due to the overlapping of an end of the crankshaft through the clutch or torque convertor it becomes possible to locate the output shaft very close to the crankshaft reducing the overall length of the engine in the direction perpendicularly to the crankshaft axis. Accordingly the accommodation of the engine in a small engine compartment as a transverse engine is facilitated and the design freedom for designing the vehicle is increased.

Advantageous embodiments of the present invention with respect to the relationship between the location of the output shaft, crankshaft and the axis of a differential mechanism which coincides with the driving front or rearwheel axle result in a further compacted structure of the engine. Thus, in case the axis of the differential mechanism is positioned lower than the axis of the crankshaft, the height of the whole engine can be kept small even if the portion of the large reduction gear of the differential mechanism projects downwardly, as the cylinder

block is inclined in such a manner that it covers the differential mechanism from the top.

According to another preferred embodiment of the present invention, the total height of the engine can be further reduced in that the axis of the differential mechanism is also positioned above a horizontal plane containing the axis of the crankshaft, enabling to prevent a portion of the large reduction gear of the differential mechanism to project downwards.

Other preferred embodiments of the present invention are laid down in the other sub-claims.

Further objectives, features and advantages of the present invention will become more apparent from the following description of embodiments of the present invention in conjunction with the associated drawings wherein:

Figure 1 is a partially sectional side view of a multi-cylinder internal combustion engine according to an embodiment of the present invention,

Figure 2 is a partially sectional plan view of the internal combustion engine of figure 1,

Figure 3 is a diagrammatic plan view of the engine of figure 1 in its built-in condition as a transverse engine in an engine compartment of a FF-vehicle,

Figure 4 is a partially sectional view of a multi-cylinder internal combustion engine according to another embodiment of the present invention,

Figure 5 is a side view (schematically) of the engine as shown in figure 4 in an built-in condition of the engine,

Figure 6 is a schematic side view of an internal combustion engine according to an embodiment of the present invention being applied to a passenger car having a midship engine system,

Figure 7 is a view similar to figure 1 showing an internal combustion engine according to another embodiment of the present invention,

Figure 8 is a partially sectional plan view similar to figure 2 showing another embodiment of the present invention,

Figure 9 is a partially sectional side view of a multi-cylinder internal combustion engine similar to figure 1 and 7, showing another embodiment of the present invention.

In the following the first embodiment of the present invention is explained together with a slight modification referring to figures 1 to 6, respectively. In this embodiment the present invention (with the exception of Fig 6) is applied to a passenger car equipped with a front-engine front-drive (FF) system. In figures 1 and 3 the engine compartment is denoted by the reference numeral 10, said engine compartment 10 being partitioned from a cockpit 14 at its rear portion by a floor panel 12 and, at its upsides, is covered by a hood 16. Reference

numerals 18 and 20 refer to a windshield and radiator, respectively.

Within the engine compartment 10 a water-cooled six cylinder row engine 22 (parallel type) is accommodated. The engine 22 is positioned substantially in between both steering front wheels 24a and 24b positioned on both sides of the engine and the vehicle body as driving wheels 24.

The engine 22 is mounted to the engine compartment 10 as a transverse engine disposed laterally on the vehicle thus, accordingly, a crankshaft 26 of the engine 22 is held by a crank case 28 and extends substantially perpendicularly to the travelling direction of the vehicle. As shown in figure 2 there are seven journal portions in total for rotatably supporting the crankshaft 26 provided between the six cylinders of the engine and at both ends of the crankshaft, said journal portions being held in between the cylinder block 28 and the crank case 30. A crank pin 31 for the second cylinder from the right side in figure 2 is held by a pair of crank arms, the one of which is shaped to constitute an engine output transmitting gear 32.

Taking the vehicle travelling direction as a basis, there is an output shaft 34 which is disposed slantly forwardly above the crankshaft 26 in parallel with the crankshaft 26 as shown in figures 1 and 2 wherein said output shaft 34 extends through a gear chamber 36 formed on the left upper front face (the right side in figure 2) of the cylinder block 28. The right end (left side in figure 2) of said output shaft 34 extends through a bearing portion 38 projected from the right upper front face (left upper front face in figure 2) of the cylinder block 28. The output shaft 34 supports a gear 40 which is in mesh with the engine output transmission gear 32 within the gear chamber 36 enabling the output shaft 34 to rotate continuously with the crankshaft 26.

On the right hand end side of the output shaft 34 a pulley 42 is fixed which is adapted to drive auxiliaries such as a water pump (not shown) for delivering engine cooling water, an oil pump (not shown) for power steering system or an air conditioning pump (not shown). Adjacent to the gear 40 the output shaft 34, moreover, supports a sprocket wheel 44, which is schematically shown only and is adapted to drive two overhead camshafts 46a and 46b. As shown in figure 1 on the top of the cylinder block 28 there is fastened a cylinder head 48 holding a countershaft 50 to which the rotation of the sprocket wheel 44 is transmitted. Consequently, the rotation of the countershaft 50 is transmitted to both camshafts 46a and 46b. In order to reduce the height of the engine 22 the cylinder block 28 is inclined backwards covering a drive axle/differential mechanism from above.

As shown in figure 3 there are six intake pipes 52 corresponding to each cylinder which extend forwardly from the top face of the cylinder head 48 and are connected to a surge tank 54 which, in turn, is connected to an air cleaner (not shown) through a throttle valve 56. The exhaust pipes bear the reference numeral 58 (figure 1).

The engine 22 is provided with a drysump lubrication system. An oil reservoir tank 60 is fastened on the front face of the crank case 30. That means the crank case 30 is composed of members 30a and 30b of the engine 22 which are joined together and the oil tank 60 is fastened to the front face of the member 30b. The lubricating oil collected within the bottom portion of the crank chamber formed between the crank case 30 and the cylinder block 28 is pumped up into the oil reservoir tank 60 by an oil pump 64 through an oil passage 62 formed through the member 30b. The oil contained in this oil reservoir tank 60 is sucked into the oil pump 64 through an oil strainer 66, force-fed to various lubricating points of the engine through an oil filter (not shown) and then is returned to the bottom portion of the crank chamber. The oil pump 64 is disposed midway on the output shaft 34 to be driven by the output shaft 34. That oil flow is marked by arrow marks in figure 1.

In case of the embodiment of figures 1 to 3 there is an automatic transmission 68 disposed on the left hand side of the cylinder block 28 and the crank case 30, having a main shaft 70 which extends coaxially with the output shaft 34. The rotation of the output shaft 34 is transmitted to the main shaft 70 through a well known transmission planetary gear system and a wet-type multi-disc clutch system arranged on this main shaft 70. The rotation of the main shaft 70 of the automatic transmission 68 is transmitted to the sub-shaft 78 through gears 74 and 76.

Slantly rearwards below the torque converter 72 a differential mechanism 80 is positioned the axis of which extends between left and right front wheels 24. As shown in figure 2 the small reduction gear 82 on the sub-shaft 78 is in permanent engagement with the large reduction gear 84 of this differential mechanism 80. The output of the differential mechanism 80 is transmitted to both front wheels 24 through a pair of left and right axle shafts 86a and 86b through constant velocity joints (not shown).

As shown in figure 1, in that case, an axis A of the differential mechanism 80 is at the same height as the axis of the crankshaft 26, i.e. coincides with a horizontal plane B containing both the axis of the crankshaft 26 and the axis of the differential mechanism 80. With respect to a notional vertical plane (not shown) containing the axis of the crankshaft 26 the output shaft 34 is disposed on a side

of the crankshaft 26 opposite to the differential mechanism 80 enabling to increase the compactness of the engine in width wise direction, i.e. the travelling direction of the vehicle. Moreover, as shown through a dot-dash line in figure 1 the large reduction gear 84 of the differential mechanism 80 does not protrude downwards from the engine 22 leaving an increased distance to the ground and increasing the designed freedom for designing the vehicle. The inclination of the cylinder block to the rear in a manner that it covers the differential mechanism from above considerably adds to obtain a small overall height of the engine.

The output shaft 34 is positioned slantly forwardly above the crankshaft 26 and the crankshaft 26 is positioned between the output shaft 34 and the axis A of the differential mechanism 80.

Figure 4 shows a partially sectional view of another embodiment of the present invention, whereas figure 5 is a side view of said another embodiment showing the engine in its mounted condition as in-built in the engine compartment. In that case the engine 22A has a torque converter 72A for the automatic transmission 68A mounted at one end of the output shaft 34A, whereas the gear system and the clutch system of the automatic transmission system 68A are accommodated within the case 80B of the differential mechanism 80A with one of the axial shafts 86B extending through this gear system and the clutch system. With such an arrangement the output of the torque converter 72A is transmitted to the gear and clutch systems through a chain 88.

Yet another embodiment of the present invention is shown in figure 6 comprising the inventive engine being applied to a passenger car provided with a midship engine system, in the present case a rear drive system. In figure 6 the reference number 100 denotes rear wheels as a pair of left and right driving wheels whereas pistons are designated through 102. In figures 4 to 6 the same reference numerals are assigned to the same portions as in figure 1 and, therefore, their respective descriptions are not repeated again.

It should be considered that the torque converter 72 or 72A provided in the engine drive system of the present invention is not necessarily required to overlap the axis of the crankshaft 26 but may be such that it overlaps only the crank web in a side view along the axis of the crankshaft 26.

Since the torque converter 72, 72A is mounted on the output shaft 34 which, in turn, is disposed slantly above the crankshaft 26 within structure according to the present invention the torque converter 72, 72A does not project downwards from the engine and the total height of the engine can be reduced. Moreover, since the output shaft 34 sup-

porting the torque converter 72,72A is disposed on a side with respect to the crankshaft 26 opposite to the differential mechanism 80,80A it becomes possible to arrange the crankshaft 26 sufficiently close to the differential mechanism 80,80A. Finally, since the torque converter 72,72A overlaps the crankshaft 26 in side view it becomes possible to arrange the output shaft (34) close to the crankshaft 26 enabling to reduce the engine dimensions in the longitudinal direction of the vehicle. Accordingly the engine 22 can be easily be mounted within a relatively small engine compartment and the design freedom for designing the vehicle is increased.

Figure 7 shows another embodiment of the present invention similar to those of figure 1. As far as the layout of said embodiment does not vary beyond that shown in figure 1 the above description of the components applies as well and is not repeated again. The most relevant difference distinguishing the embodiment of figure 7 beyond those of figure 1 refers to the disposal of the differential mechanism 80 which, in that case, is positioned lower than the axis of the crankshaft 26, i.e. lower than a horizontal plane B containing the axis of the crankshaft 26. Although the position of the differential mechanism 80, in particular the large reduction gear 84 thereof will become lower accordingly, the total height of the engine 22 can be kept small as the cylinder block 28 thereof is inclined backwards in such a manner that it covers the differential mechanism 80 from above. Again the output shaft 34 is positioned slantly forwardly above the crankshaft 26 and the torque converter 72 therein overlaps the crankshaft 26 in side view, with the crankshaft 26 being positioned between the output shaft 34 and the axis A of the differential mechanism 80. Thus, the torque converter 72 having a large diameter does not interfere with the differential mechanism 80 or an axle shaft (not shown) enabling to dispose the output shaft 34 close to the crankshaft 26.

Even though the torque converter 72 in this embodiment has been shown to overlap the axis of the crankshaft 26 in side view it may be such that it overlaps the crank web, respectively.

Another embodiment of the present invention (in plan view similar to figure 2) is shown in figure 8. This embodiment distinguishes in that a manual transmission 68A having a single disc dry foot clutch 72A forming the rotating member of large diameter is used instead of the automatic transmission 68. So far the same reference numerals were assigned to the same parts as in the embodiment of figure 2 and, accordingly, their descriptions are not repeated.

Finally yet another, specifically preferred embodiment of the present invention is shown in fig-

ure 9 disclosing the axis A of the differential mechanism 80 to be located higher than the axis of the crankshaft 26, i.e. higher than a horizontal plane B which contains the axis of the crankshaft 26. Accordingly, the differential mechanism 80 having large reduction gear 84 of large diameter does not project downwards from the engine 22. Thus an increased compactness of the engine 22 is assured. As is evident said embodiments can also be combined with the provision of a manual transmission 68A and the layout shown in figure 8.

In view of the further aspects and features of said embodiment the above explanations given with respect to figures 1 and 7 apply as well.

Again, since the main shaft 70 of the transmission 68 is disposed on the level of the output shafts 34 which, in turn, is positioned in parallel and slantly above the crankshaft 26 the torque converter or the clutch, positioned on that level will not project downwards from the engine 22. Moreover, since the axis of a differential mechanism 80,80A is also positioned higher than the crankshaft 26 the large reduction gear of the differential mechanism 80,80A, does not project downwards from the engine resulting in a compact design of said engine having a reduced overall height. The output shaft 34 supporting the torque converter or the clutch is positioned on a side with respect to the crankshaft 26 opposite to the differential mechanism 80 and, therefore, it is possible to arrange the crankshaft 26 sufficiently close to the differential mechanism 80 and, moreover, as the clutch or torque converter overlaps the crankshaft in the side view an arrangement of the output shaft 34 close to the crankshaft 26 is facilitated reducing the dimensions of the engine 22 in longitudinal direction of the vehicle. Accordingly, the engine can be easily mounted within a small engine compartment.

#### Claims

1. An multi-cylinder internal combustion engine for vehicles for accommodation in an engine compartment in transverse arrangement substantially in between a pair of left and right driving wheels, with a crankshaft extending substantially perpendicularly to the travelling direction of the vehicle transmitting the engine output to said pair of left and right driving wheels through a transmission and a differential mechanism, and an output shaft which is disposed in parallel with the crankshaft and is driven by the crankshaft wherein the transmission is supported by a main shaft extending substantially coaxially to the output shaft,  
**characterized in that,**  
 the differential mechanism (80,80A), with respect to a vertical plane containing the axis of the crank-

shaft (26) is disposed on a side opposite to the output shaft (34) which, in turn, supports a rotating member (72,72A) having a large diameter radially projecting to overlap the end of the crankshaft/crank web-structure (26,32) while the cylinder block (28) is inclined such that it covers the differential mechanism (80,80A,84) from above.

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2. A multi-cylinder internal combustion engine as claimed in claim 1,

**characterized in that,**

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an axis (A) of the differential mechanism (80,80A) is positioned higher than a horizontal plane (B) containing the axis of the crankshaft (26).

3. A multi-cylinder internal combustion engine as claimed in claim 1,

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**characterized in that,**

an axis (A) of the differential mechanism (80,80A) is positioned lower than a horizontal plane (B) containing the axis of the crankshaft (26).

4. A multi-cylinder internal combustion engine as claimed in claim 1,

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**characterized in that,**

an axis (A) of the differential mechanism (80,80A) is positioned substantially at the same height as the axis of the crankshaft (26) coinciding with horizontal plane (B) containing the axis of the crankshaft (26).

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5. A multi-cylinder internal combustion engine as claimed in at least one of the preceding claims 1 to 4,

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**characterized in that,**

the rotating member of large diameter is a torque converter (72A) of an automatic transmission or a clutch (72) of a gear transmission (74).

6. A multi-cylinder internal combustion engine as claimed in at least one of the preceding claims 1 to 5,

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**characterized in that,**

a gear system and a clutch system of an automatic transmission (68A) are accommodated within a separated case (80B) for the differential mechanism (80A), with the one of a pair of axle shafts (86A, 86B) of the driving wheels (24) extending outwards through said gear and clutch systems, whereas the output of the torque converter (72A) is transmitted to the gear and clutch systems through a chain (88).

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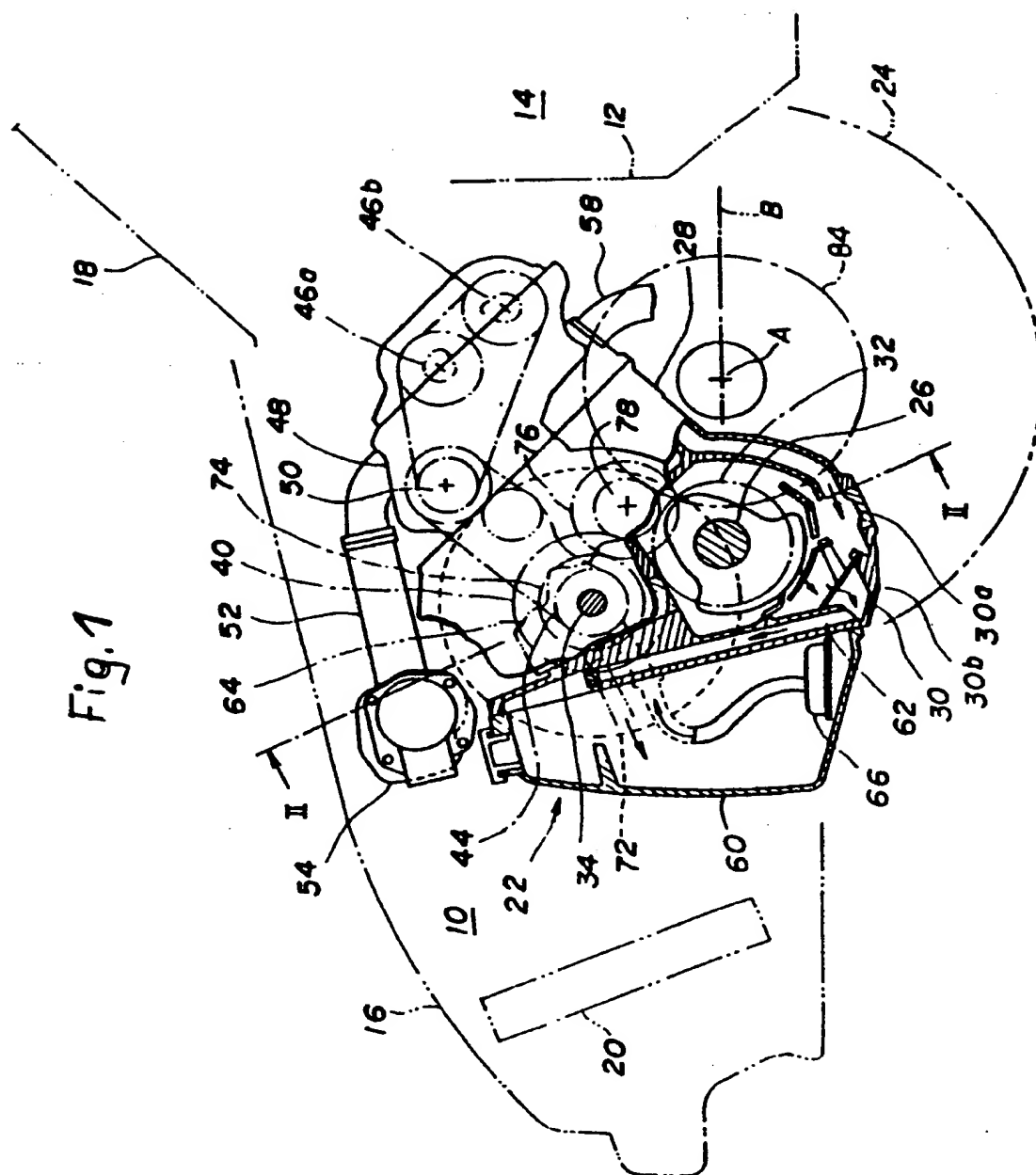
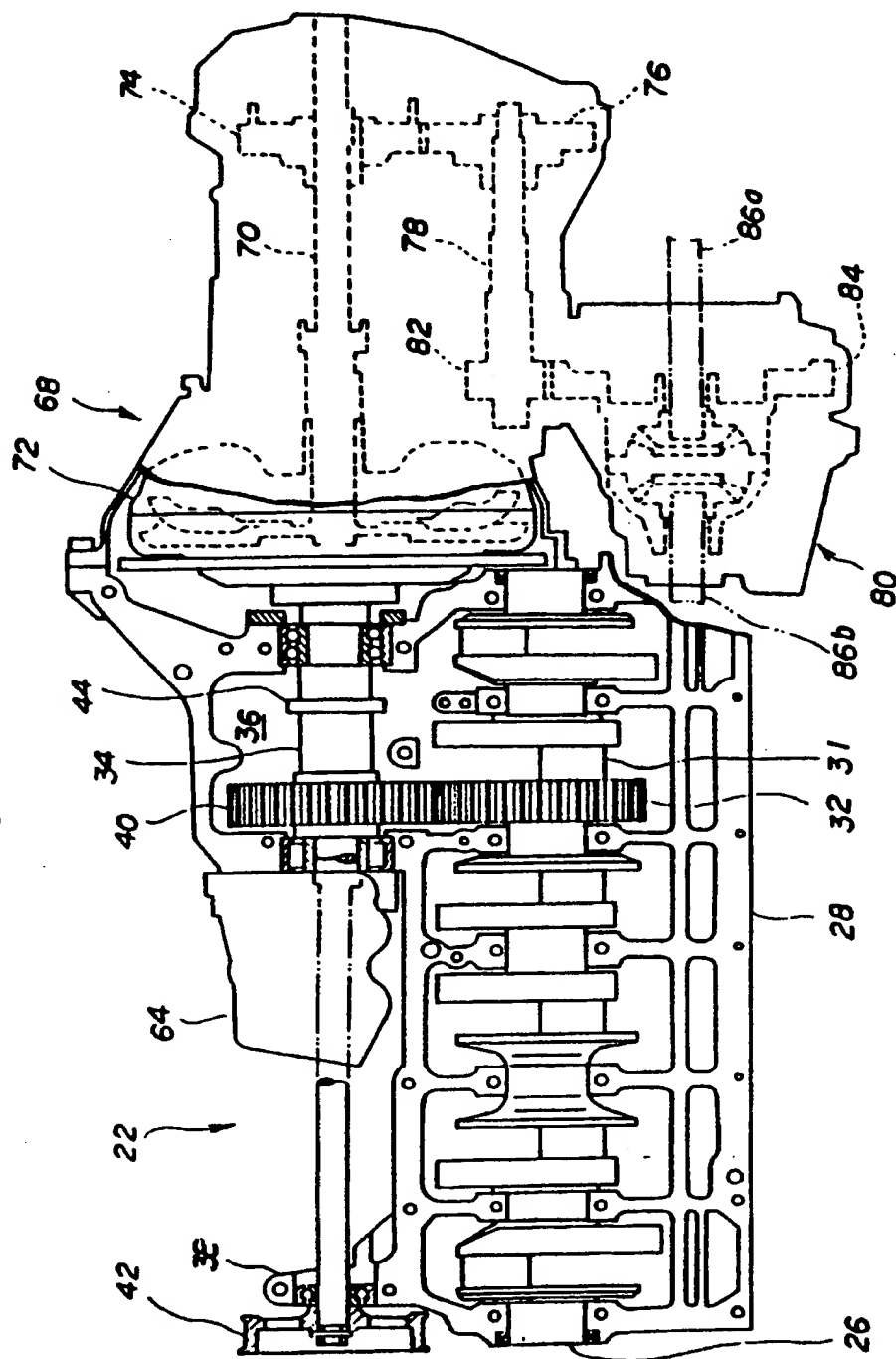


Fig. 2





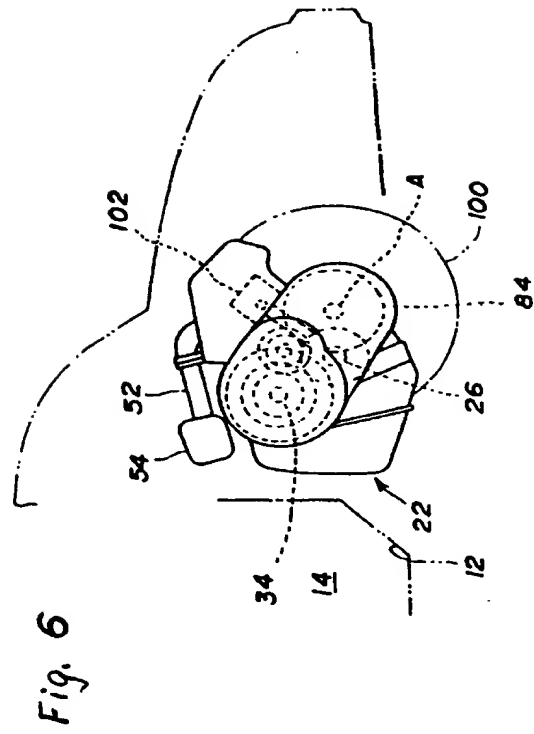
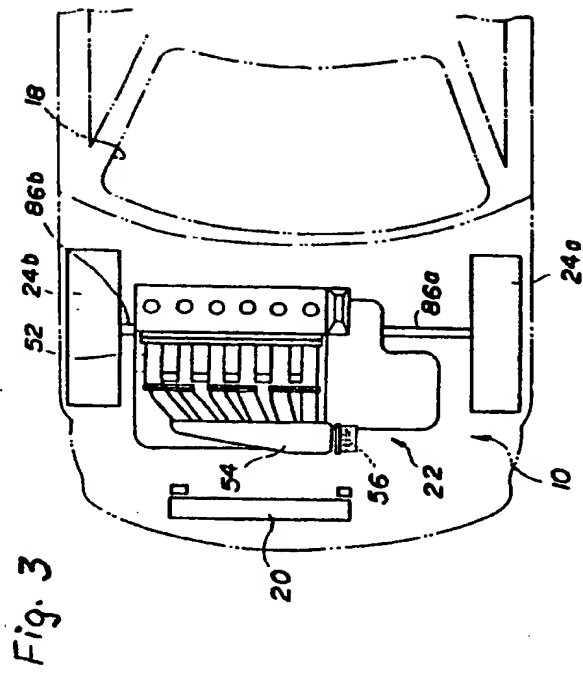
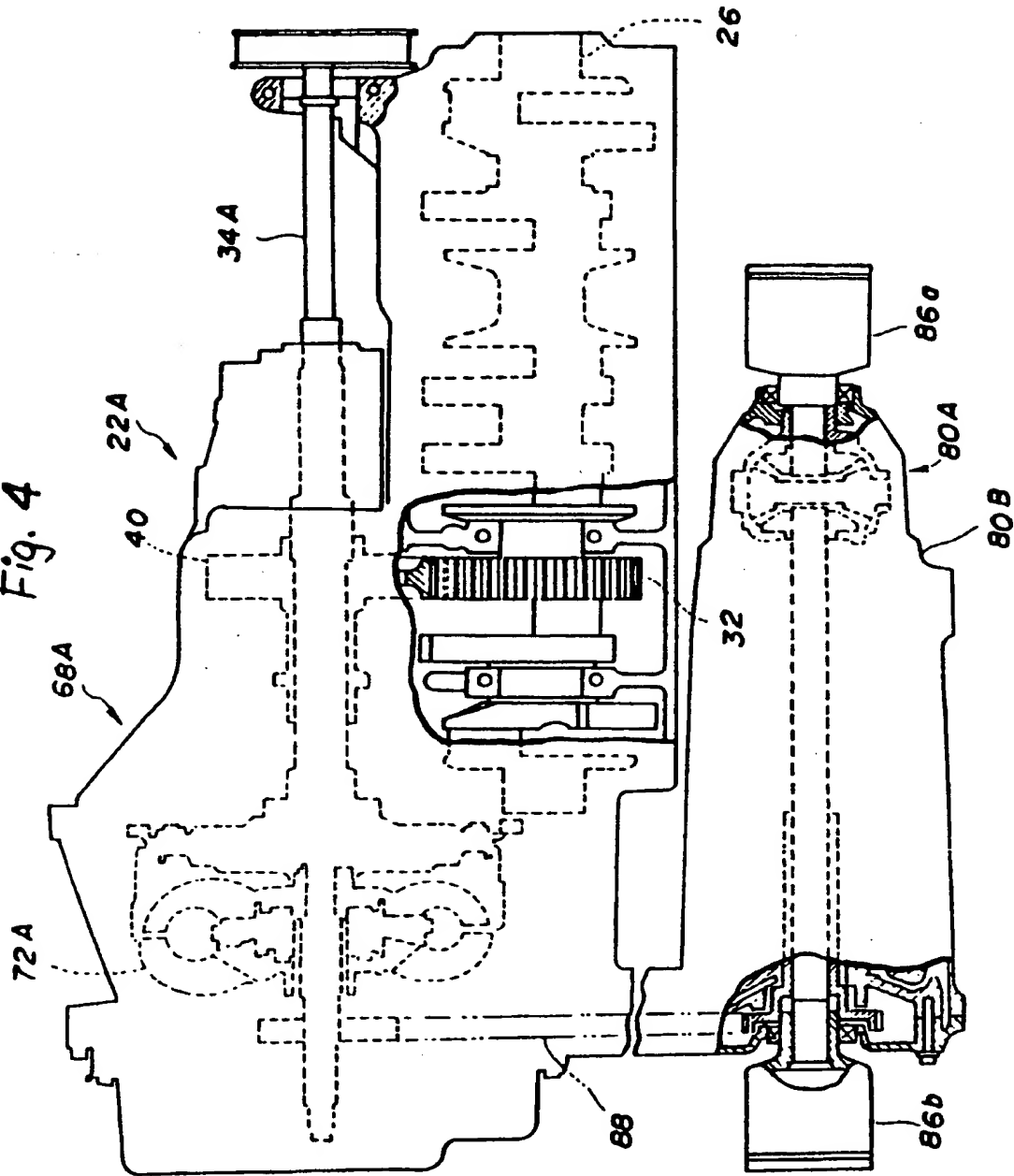
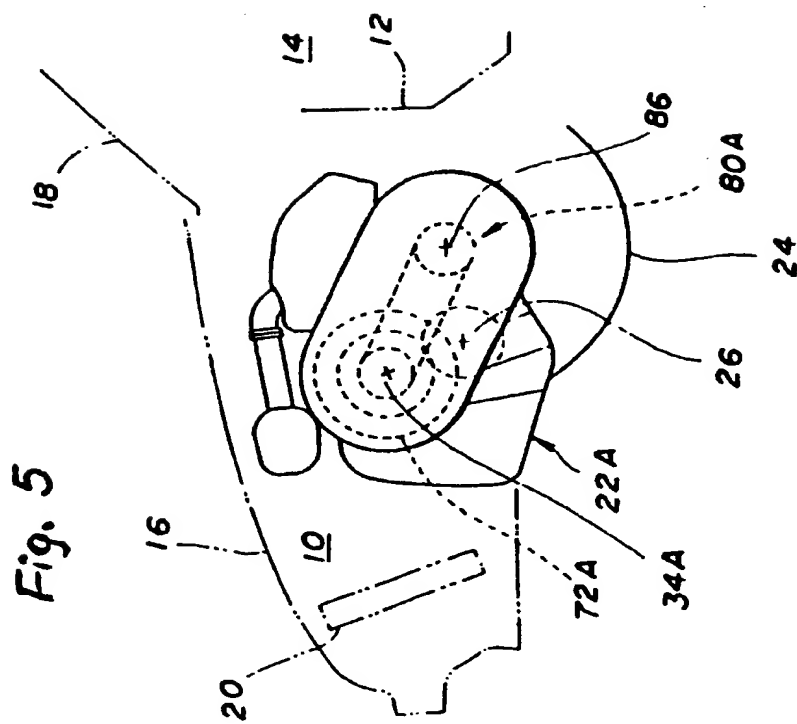


Fig. 4





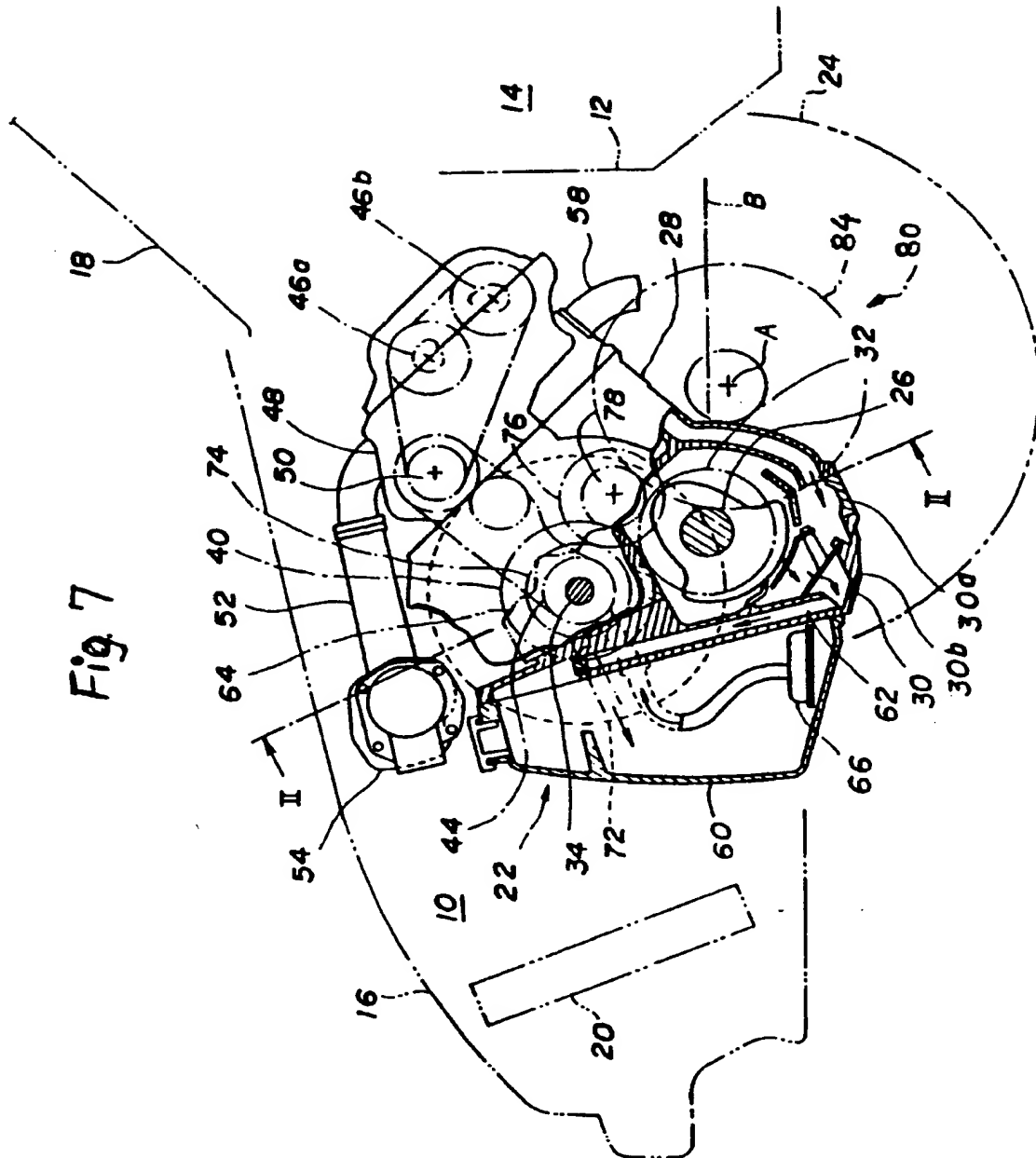
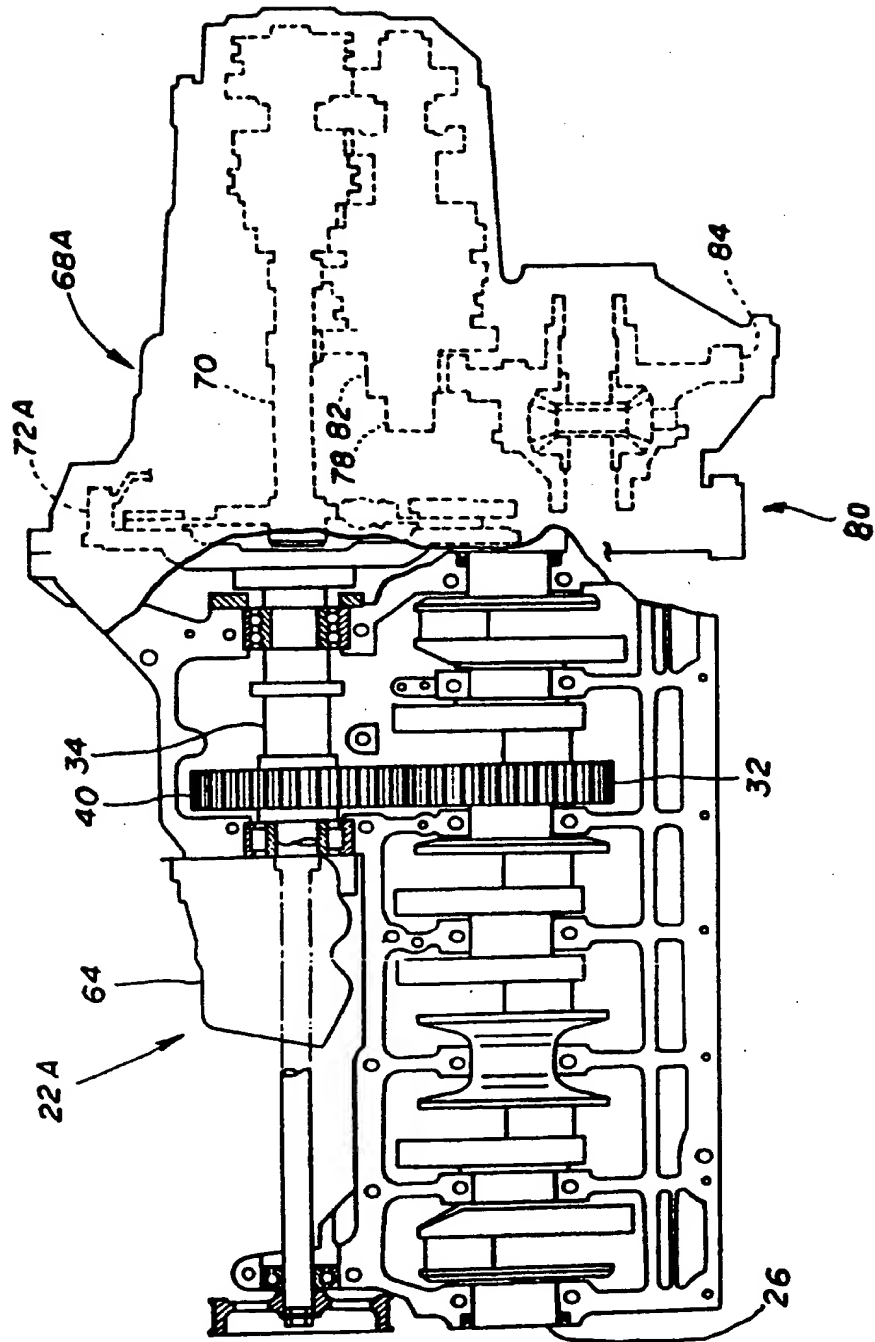
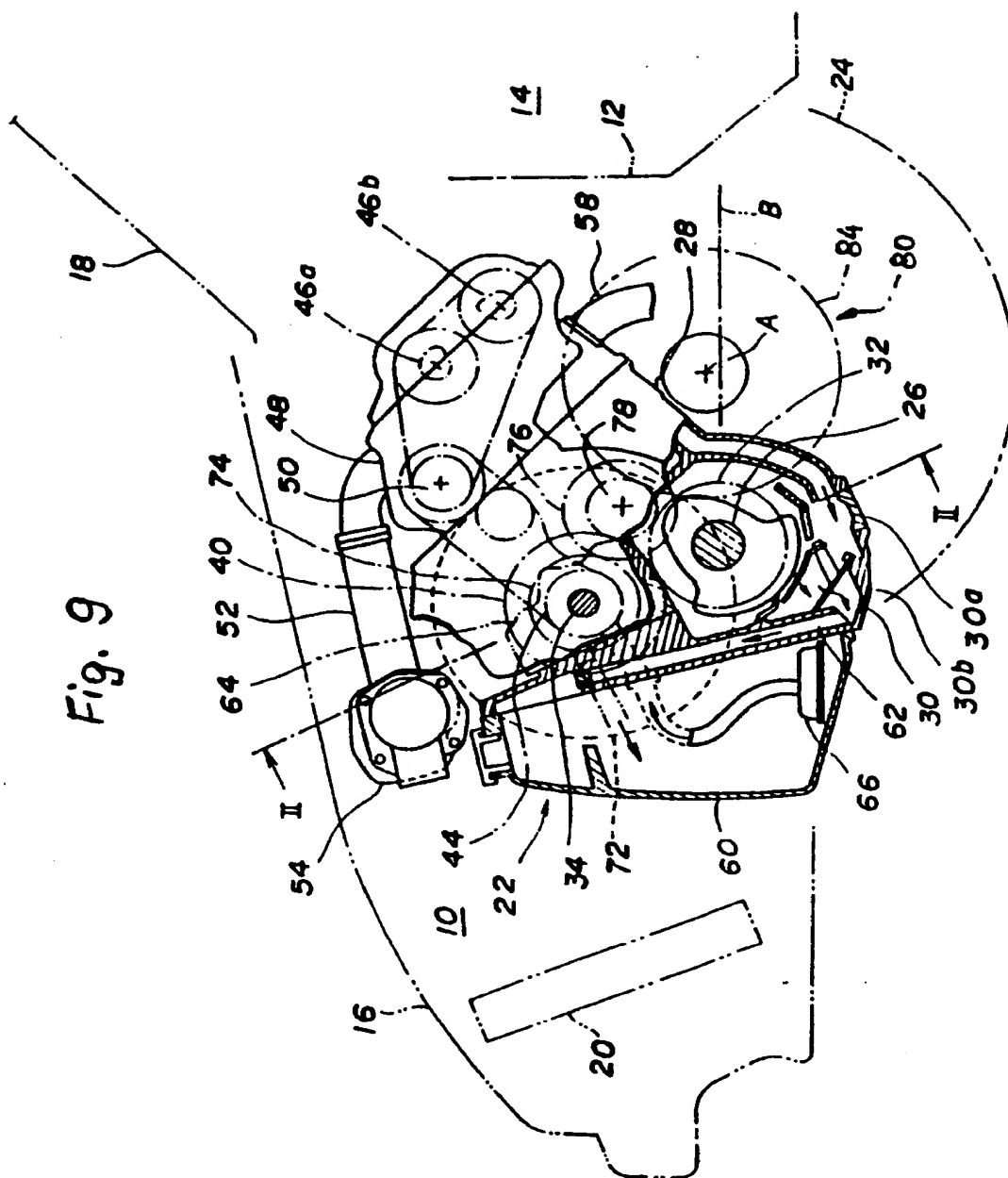


Fig. 8







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## EUROPEAN SEARCH REPORT

Application Number

EP 90 11 7224

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. CL.5)
X	EP-A-0318971 (YAMAHA) * the whole document *	1, 3-6	B60K5/04
X	DE-C-381331 (TAP) * the whole document *	1, 3, 5	
X	US-A-3150543 (DANGAUTHIER) * figures 3, 4 *	1, 3	
A	DE-A-2149444 (KLAUE) * figures *	1	
A	EP-A-0281693 (LINGS)		
			TECHNICAL FIELDS SEARCHED (Int. CL.5)
			B60K F02B
The present search report has been drawn up for all claims			
Place of search BERLIN		Date of completion of the search 30 NOVEMBER 1990	Examiner KRIEGER, P
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